Preliminary Data Sheet 6.039

INTERNATIONAL RECTIFIER IOR

FULLY PROTECTED DMOS POWER SWITCH

IRSF3011

SMARTFET™ Transistor

General Description:

The IRSF3011 is a 3 terminal monolithic SMART POWER MOSFET with built in short circuit, over-temperature, ESD and over-voltage protections.

The on chip protection circuit latches off the POWER MOSFET in case the drain current exceeds 7A (typical) or the junction temperature exceeds 165°C (typical) and keeps it off until the input is driven low. The drain to source voltage is actively clamped at 55V (typical), prior to the avalanche of POWER MOSFET, thus improving its performance during turn off with inductive loads.

The input current requirements are very low (300μA) which makes the IRSF3011 compatible with most existing designs based on standard POWER MOSFETs.

Rating Summary:

$V_{ds(clamp)}$	50V
$R_{ds(on)}$	200 mΩ
Ids(sd)	5 A
$T_{j(sd)}$	155° C
E_{AS}	200 mJ

APPLICATIONS:

- Solenoid Driver
- DC Motor Driver
- Lamp Driver

FEATURES:

- Extremely Rugged for Harsh Operating Environment.
- Over Temperature Protection.
- Over Current Protection.
- Active Drain to Source Clamp.
- ESD Protection.
- Logic Level Input Threshold.
- Compatible with standard POWER MOSFET.
- Monolithic Construction.

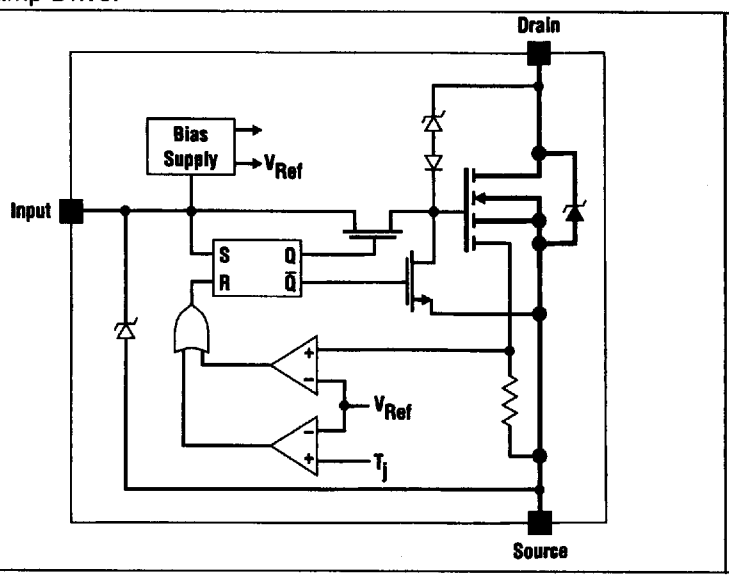

Fig 1. - Block Diagram

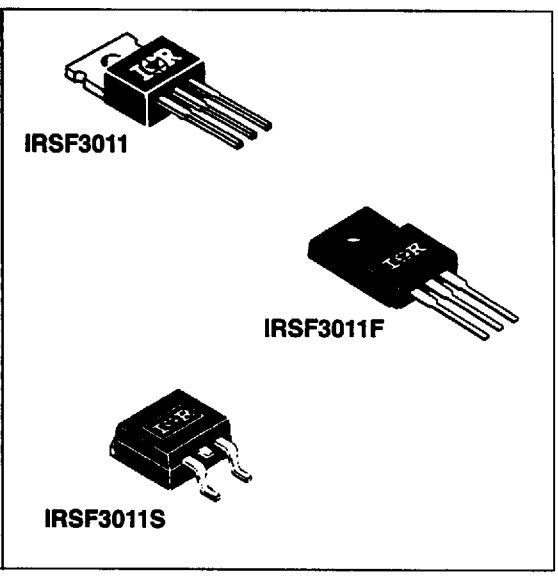

Fig 2. - Available packages

IRSF3011

ABSOLUTE MAXIMUM RATINGS:

Absolute Maximum Ratings indicate sustained limits beyond which damage to the device may occur.
(T_C = 25°C unless otherwise specified.)

Symbol	Parameter	Min.	Max.	Units	Conditions
$V_{ds,max}$	Continuous Drain to Source Voltage	—	50	V	
$V_{in,max}$	Continuous Input Voltage	0	10		
I_{ds}	Continuous Drain Current	—	self limited		
P_D	Power Dissipation (IRSF3011)	—	30	W	$T_C \leq 25°C$
	Power Dissipation (IRSF3011F)	—	20		
	Power Dissipation (IRSF3011S)	—	30		
	Power Dissipation (IRSF3011S, PCB Mount)①	—	3		
E_{AS}	Unclamped Single Pulse Inductive Energy ②	—	200	mJ	
V_{esd1}	Electrostatic Discharge Voltage (Human Body Model)	—	4000	V	100pF, 1.5kΩ
V_{esd2}	(Machine Model)	—	1000		200pF, 0Ω
T_{jop}	Operating Junction Temperature Range	-55	150	°C	
T_{stg}	Storage Temperature Range	-55	150		
	Lead Temperature (Soldering, 10 seconds)	—	300		

STATIC ELECTRICAL CHARACTERISTICS:

(T_C = 25°C unless otherwise specified.)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$V_{ds,clamp}$	Drain to Source Clamp Voltage	50	54	—	V	I_{ds} = 10 mA
		—	56	62		I_{ds} = 6A, t_p = 700 µS
$R_{ds(on)}$	Drain to Source On Resistance	—	155	200	mΩ	V_{in} = 5 V, I_{ds} = 2A
		—	200	—		V_{in} = 4 V, I_{ds} = 2 A
		—	115	—		V_{in} = 10 V, I_{ds} = 2A
I_{dss}	Drain to Source Leakage Current	—	—	10	µA	V_{ds} = 12 V, V_{in} = 0 V
		—	—	100		V_{ds} = 50 V, V_{in} = 0 V
		—	10	250		V_{ds} = 40 V, V_{in} = 0 V, T_C = 150°C
V_{th}	Input Threshold Voltage	1.5	2.0	2.5	V	V_{ds} = 5 V, I_{ds} = 10mA
$I_{i,on}$	Input Supply Current (Normal Operation)	—	0.25	0.6	mA	V_{in} = 5 V,
		—	0.35	0.85		V_{in} = 10 V
$I_{i,off}$	Input Supply Current (Protection Mode)	—	0.5	1.0		V_{in} = 5 V,
		—	0.6	1.2		V_{in} = 10 V
$V_{in,clamp}$	Input Clamp Voltage	10	10.8	—	V	I_{in} = 10 mA
V_{sd}	Body-Drain Diode Forward Drop ③	—	1.2	1.5		Ids = -9A , Rin = 1kΩ

THERMAL RESISTANCE:

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$R_{\theta JC}$	Junction to Case (IRSF3011)	—	—	4	°C/W	
	Junction to Case (IRSF3011F)	—	—	6		
	Junction to Case (IRSF3011S)	—	—	4		
$R_{\theta JA}$	Junction to Ambient (IRSF3011)	—	—	62		
	Junction to Ambient (IRSF3011F)	—	—	65		
	Junction to Ambient (IRSF3011S)	—	—	62		
	Junction to Ambient (IRSF3011S, PCB Mount)①	—	—	40		

SWITCHING ELECTRICAL CHARACTERISTICS:

(V_{CC} = 14V, Resistive Load R_L = 10Ω, Tc = 25°C) Please refer to Figure 15 for switching time definitions.

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
t_{don}	Turn-On Delay time	—	160	250	nS	V_{in} = 5V
		—	90	—		V_{in} = 10V
t_r	Rise Time	—	650	1200		V_{in} = 5V
		—	250	—		V_{in} = 10V
t_{doff}	Turn-Off Delay time	—	250	350		V_{in} = 5V
		—	300	—		V_{in} = 10V
t_f	Fall Time	—	180	350		Vin = 5V
		—	170	—		Vin = 10V

PROTECTION CHARACTERISTICS:

(Tc = 25°C, unless otherwise specified.)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_{ds(sd)}$	Over-Current Shutdown Threshold	5	7.5	10	A	V_{in} = 5V
$T_{j(sd)}$	Over Temperature Shutdown Threshold	155	165	—	°C	V_{in} = 5 V, I_{ds} = 1 A
$V_{protect}$	Minimum Input Voltage for Over-Temp Functionality	—	3	—	V	
t_{Iresp}	Over-Current Response Time	—	4	—	µS	See figure 16 for definition
t_{Iblank}	Over-Current Blanking Time	—	4	—		See figure 16 for definition
I_{peak}	Peak Short Circuit Current	—	16	—	A	See figure 16 for definition
V_{reset}	Protection Reset Voltage	—	1.3	—	V	
t_{reset}	Protection Reset Time	—	8	—	µS	See figure 17 for definition
t_{Tresp}	Over-Temperature Response Time	—	12	—		See figure 18 for definition

TEMPERATURE COEFFICIENTS OF ELECTRICAL CHARACTERISTICS:

Please see Figures 3 through 14 for more data on thermal characteristics of other electrical parameters.

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$V_{ds,clamp}$	Temperature Coefficient of Drain to Source Clamp Voltage	—	18.2	—	mV/°C	I_{ds} = 10 mA
Vth	Temperature Coefficient of Input Threshold Voltage	—	-2.7	—		V_{ds} = 5 V, I_{ds} = 10mA
Vin,clamp	Temperature Coefficient of Input Clamp Voltage	—	7.0	—		I_{in} = 10 mA
$I_{ds(sd)}$	Temperature Coefficient of Over-Current Shutdown Threshold	—	-9.8	—	mA/°C	V_{in} = 5V

Notes :

1. When mounted on 1" square PCB(FR-4 or G10 material). For recommended footprint and soldering techniques refer to application note AN-994.
2. E_{AS} is tested with a constant current source of 6A applied for 700 µs with V_{in} = 0V and starting T_j = 25°C.
3. Input current must be limited to less than 5 mA with a 1kΩ resistor in series with the input when the Body-Drain Diode is forward biased.

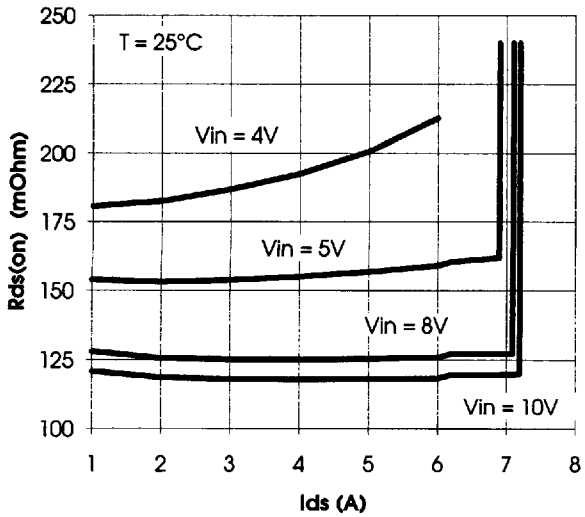

Fig. 3 - On Resistance vs Drain to Source Current.

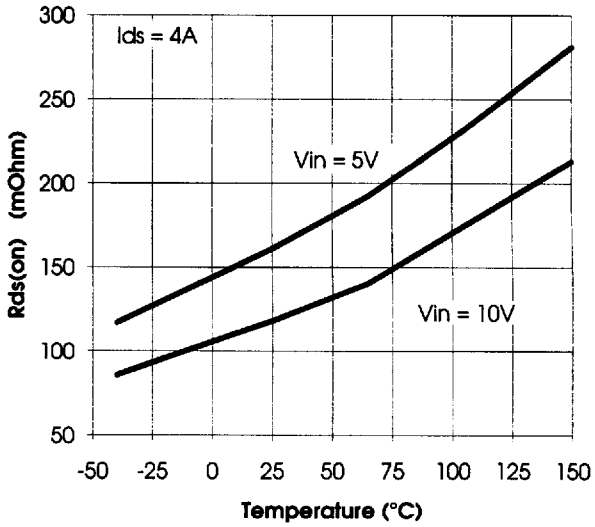

Fig. 4 - On Resistance vs. Temperature

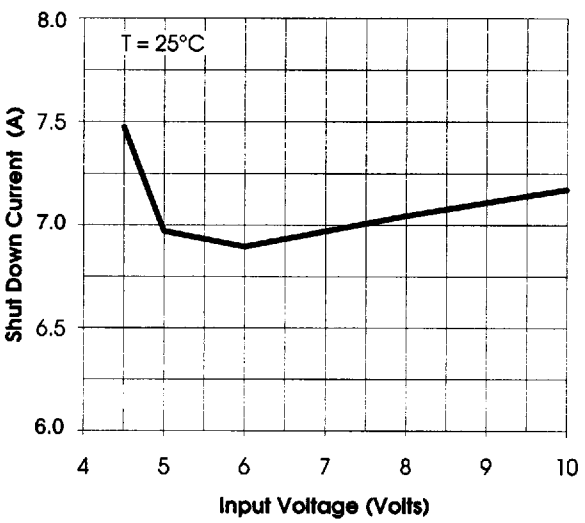

Fig. 5 - Over-current Shutdown Threshold vs Input Voltage

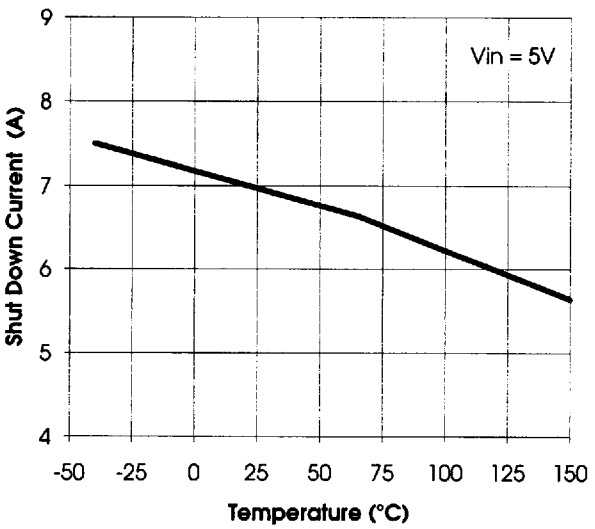

Fig. 6 - Over-current Shutdown Threshold vs Temperature

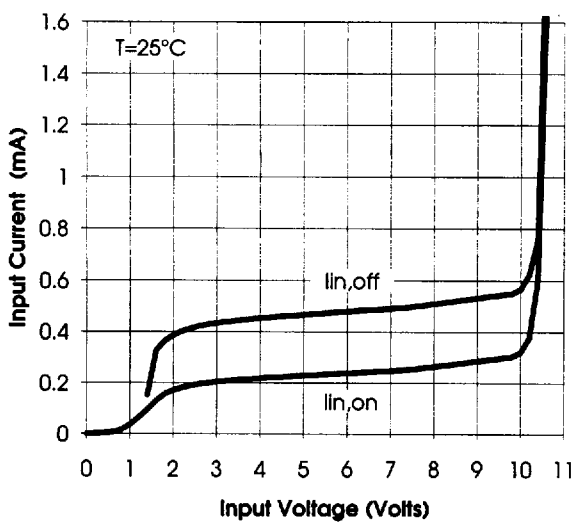

Fig. 7 - Input Current vs. Input Voltage

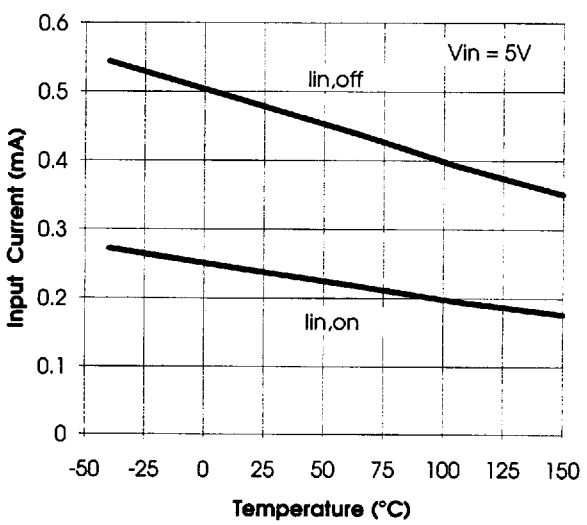

Fig. 8 - Input Current vs. Temperature

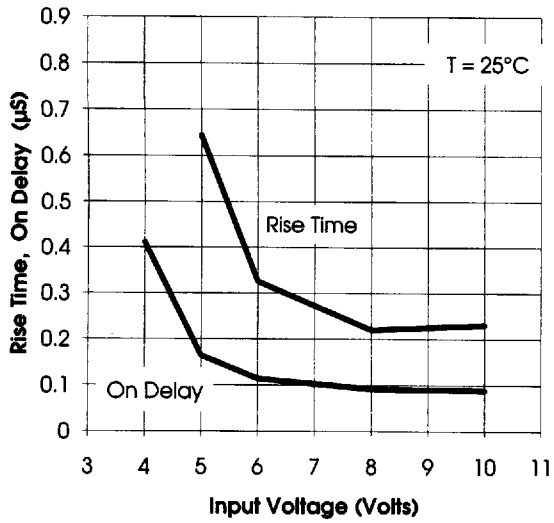

Fig. 9 - Turn on characteristics vs Input Voltage

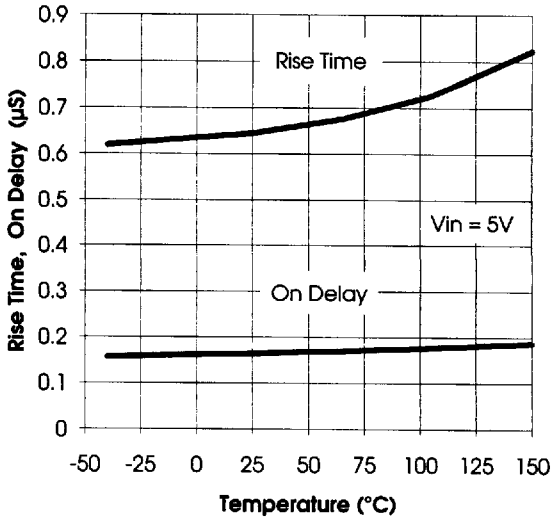

Fig. 10 - Turn on characteristics vs Temperature

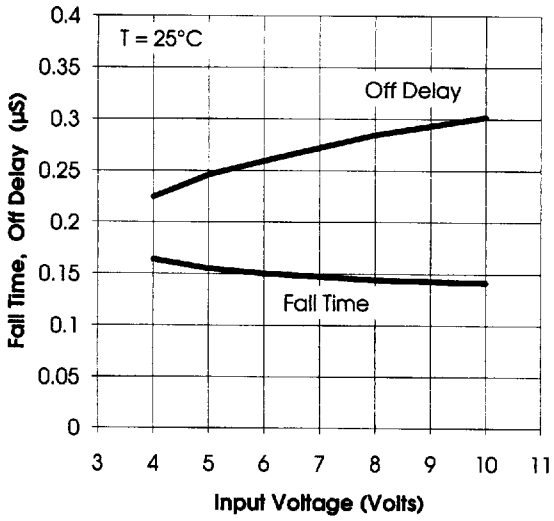

Fig. 11 - Turn off characteristics vs Input Voltage

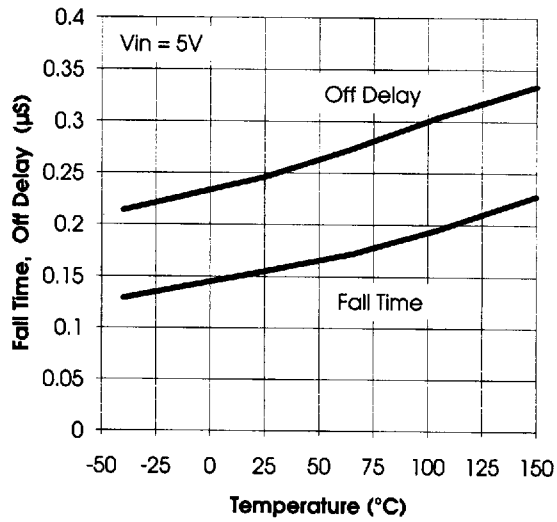

Fig. 12 - Turn off characteristics vs Temperature

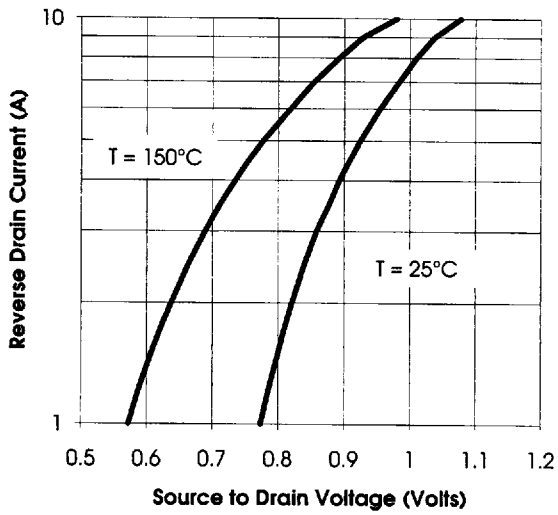

Fig. 13 - Source-Drain Diode Forward Voltage

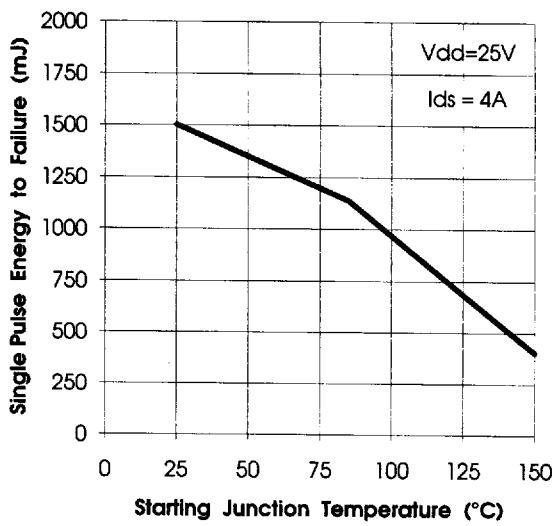

Fig. 14 - Unclamped Single Pulse Inductive Energy to Failure vs. Starting Junction Temperature

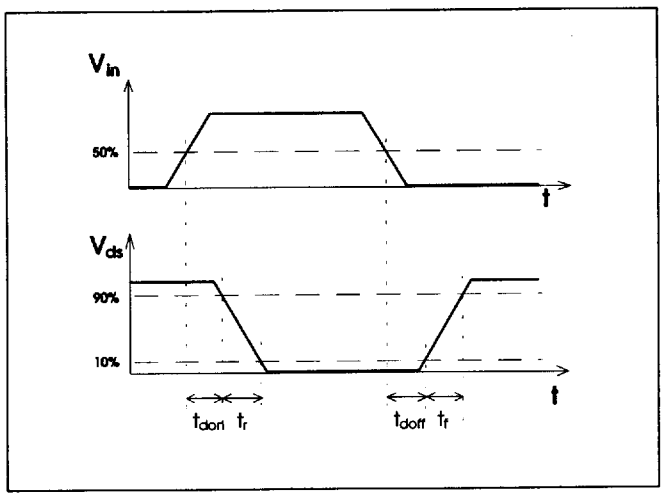

Fig. 15 - Definition of Switching times

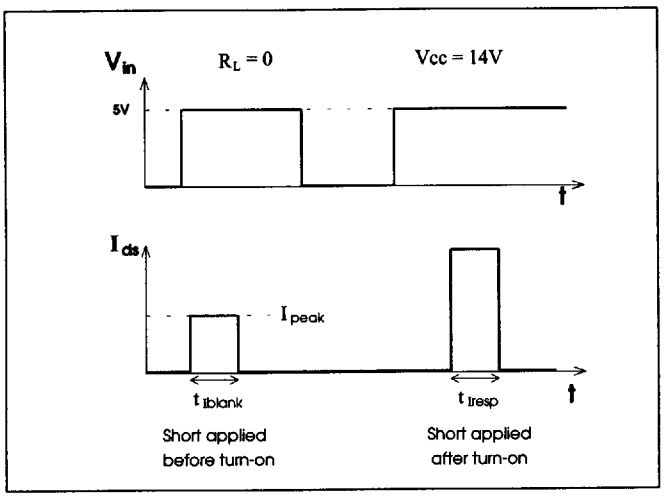

Fig. 16 - Definition of I_{peak}, t_{Iblank}, t_{Iresp}

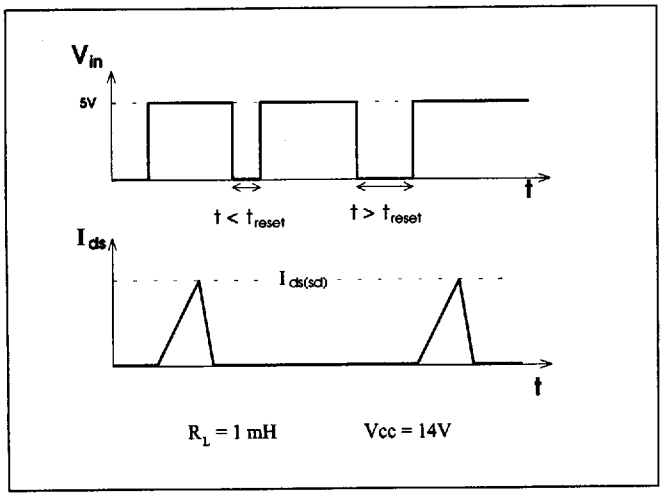

Fig. 17 - Definition of t_{reset}

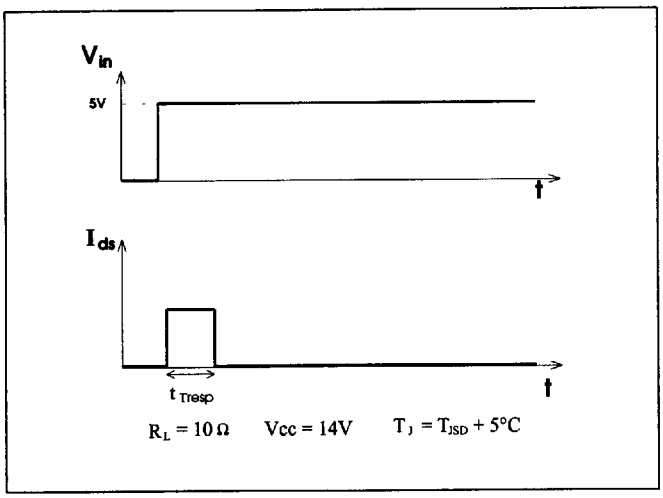

Fig. 18 - Definition of t_{Tresp}

Introduction

Protected monolithic POWER MOSFETs offer simple, cost-effective solution in applications where extreme operating conditions can occur. The margin between the operating and the absolute maximum values can be narrowed resulting in better utilization of the device and lower cost. The ESD protection reduces the off-circuit failures during handling and assembly.

General Description

The IRSF3011 is a fully protected monolithic N-channel, logic level POWER MOSFET with 200 mΩ (max) on-resistance. The built-in protections include over-current, over-temperature, ESD and over-voltage protections.

The over-current and over-temperature protection makes the IRSF3011 indestructible at any load conditions in switching or in linear applications. The built-in ESD protection minimizes the risk of ESD damage when the device is off-circuit. The IRSF3011 is fully characterized for avalanche operation, and can be used for fast de-energization of inductive loads.

The IRSF3011 SmartFET available in TO220 package, offers easy upgrade from non-protected devices.

Block Diagram

The zener diode between the input and the source (see figure 19) provides the ESD protection for the input and also limits the applicable voltage to the input to 10V.

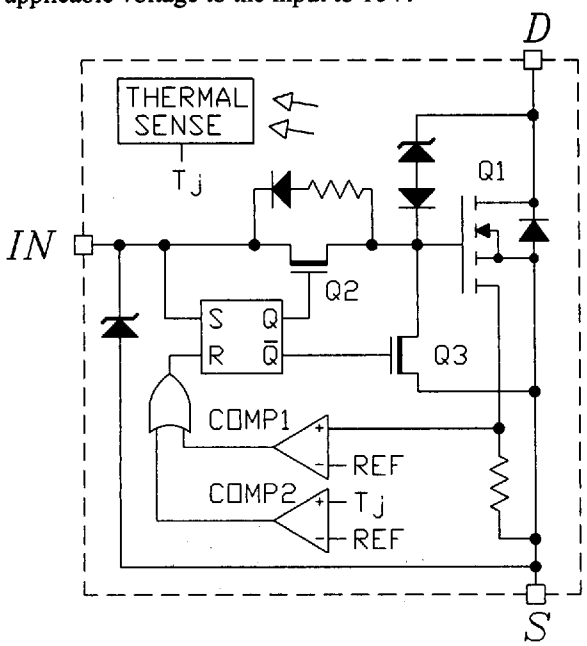

Fig. 19 - Block diagram

The R-S flip-flop memorizes the occurrence of an error condition and controls Q2 and Q3 switches. The flip-flop can be cleared by holding the input low for the specified minimum duration.

COMP1 and COMP2 comparators are used to compare the over-current and over temperature signals with the built-in reference. Either comparator can reset the fault flip-flop and turn Q1 off. During fault condition, Q2 disconnects gate of Q1 from the input, Q3 shorts the gate and source of Q1, resulting rapid turn-off of Q1. The zener diode between the gate and drain of Q1 turns Q1 on, when the drain to source voltage exceeds 55V.

Switching Characteristics

In the IRSF3011 the control logic and the protection circuits are powered from the input pin. When positive voltage appears at the input pin the R-S flip-flop turns Q2 on and connects the gate of the main device to the input

The turn-on speed is limited by the channel resistance of Q2 and the gate charge requirement of Q1. The typical switching waveforms at 5V input voltage are shown in figure 20.

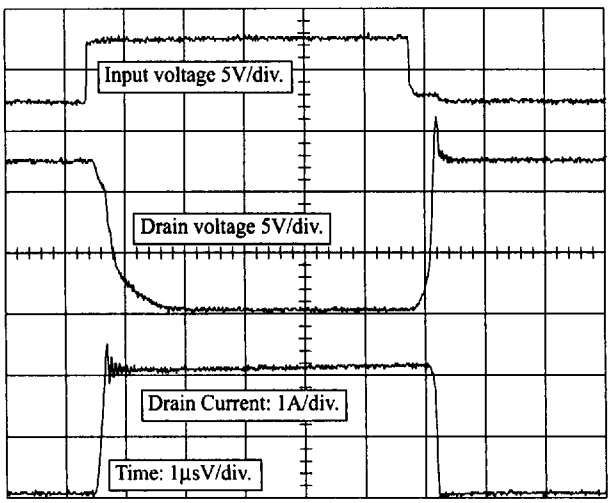

Fig. 20 - Waveforms switching clamped inductive load using 5V input voltage.

Using higher input voltage will improve the turn-on time but it does not affect the turn-off switching speed.

The typical waveforms at 7V input voltage are shown in figure 21. In typical switching applications, below 60kHz, the difference in switching losses between the IRSF3011 and the same size standard MOSFET is negligible.

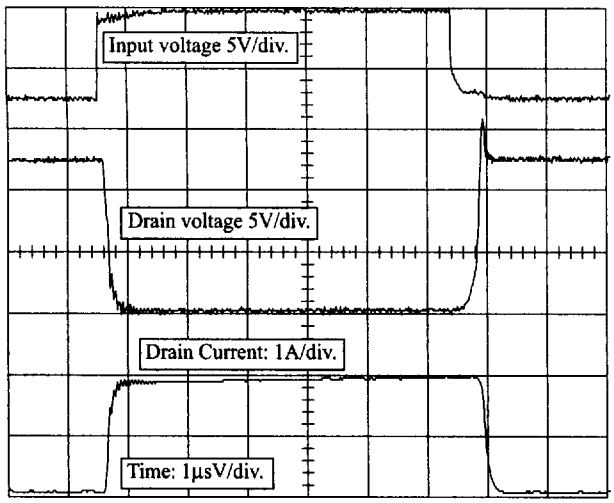

Fig. 21 - Switching waveforms with 7V input voltage

Over-current Protection

When the drain current exceeds the preset limit the protection circuit resets the internal flip-flop and turns Q1 off. The normal operation can be restored by holding the input voltage below the specified threshold level (approximately 1.3V) for the specified minimum t_{reset} time.

The typical waveforms at over-current shut-down are shown in figure 22. After turn-on the current in the inductor at the drain starts ramping up. At about 7A the over-current protection shuts down the device.

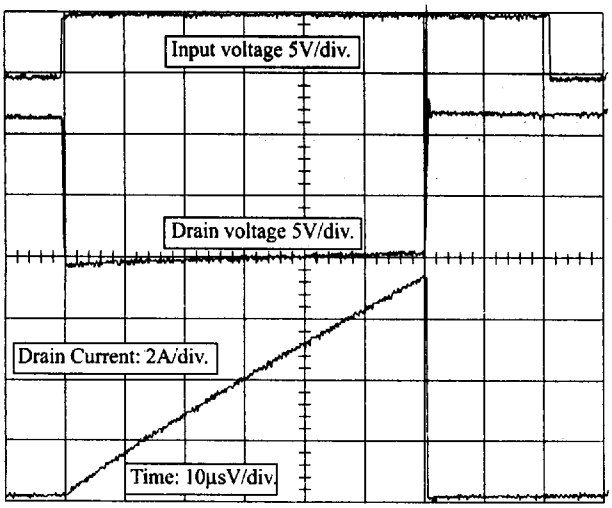

Fig. 22 - Waveforms at Over-current shut-down

Over-temperature Protection

Figure 23 illustrates the operation of the over temperature protection. The IRSF3011 switches a 2Ω resistive load to a 10V power supply. When the thermal balance is established the junction temperature is limited on pulse by pulse basis.

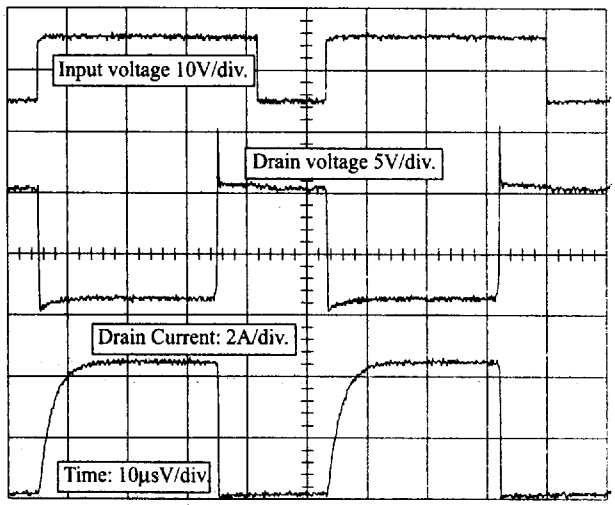

Fig. 23 - Over-temperature shut-down

Over-voltage Protection

When the drain to source voltage exceeds 55V the zener diode between the gate and drain turns the IRSF3011 on, before the breakdown voltage of the drain-source diode is reached. This greatly enhances the energy the device can withstand safely during turn-off of inductive loads. The absorbed energy is limited only by the maximum junction temperature. This feature makes IRSF3011 ideal for fast de-energization of inductive loads

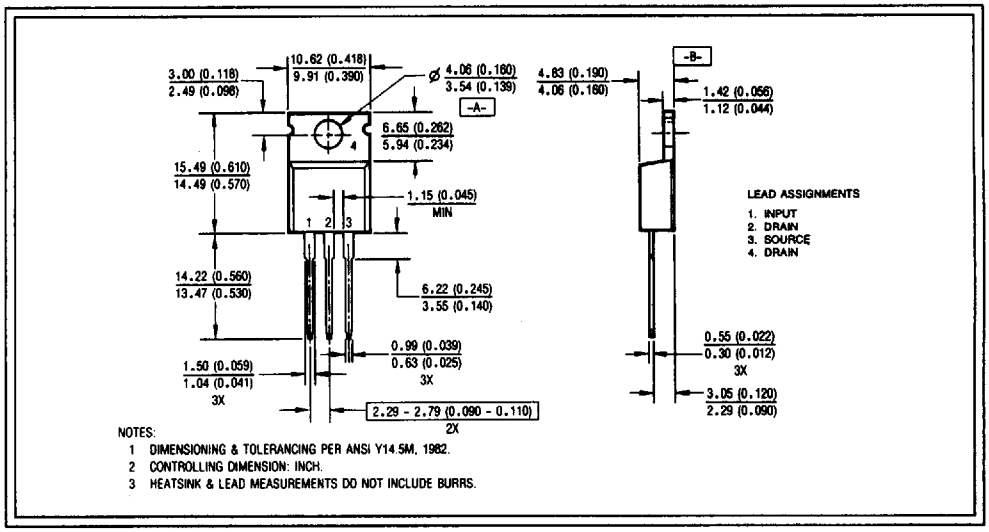

Figure 24a - IRSF3011 (TO-220AB)

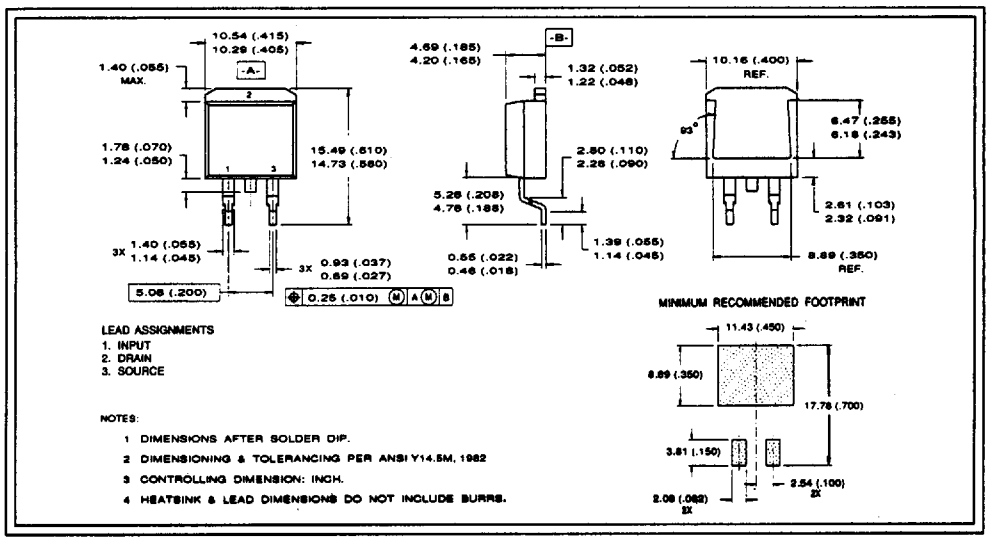

Figure 24b - IRSF3011S (SMD-220)

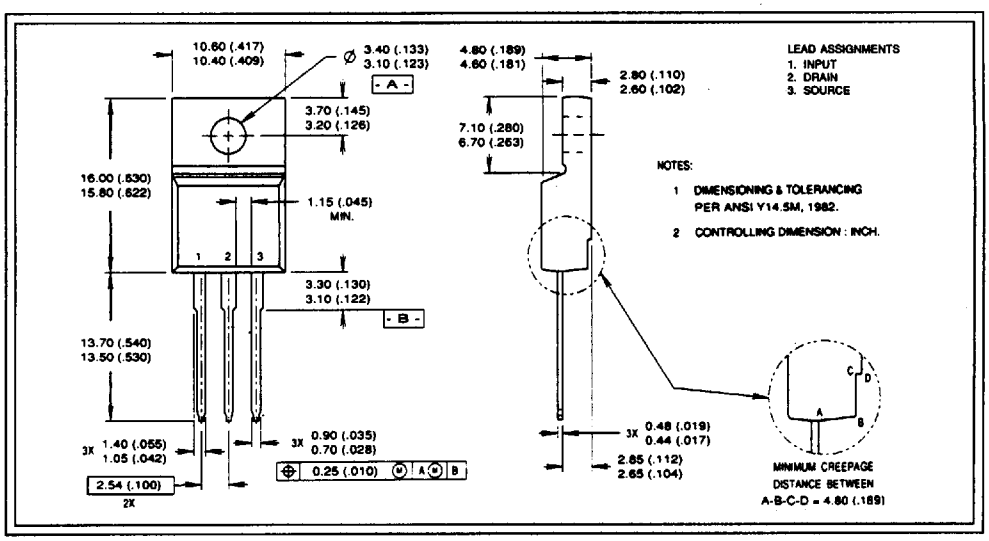

Figure 24c - IRSF3011F (TO-220 Full-Pak)